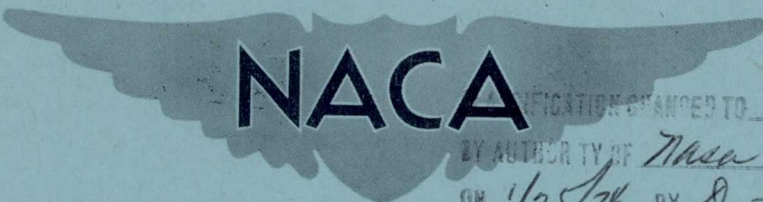


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RESEARCH MEMORANDUM

HEAT OF COMBUSTION OF THE PRODUCT FORMED BY THE
REACTION OF ACETYLENE, ETHYLENE, AND DIBORANE

By Stanley Tannenbaum

Lewis Flight Propulsion Laboratory
Cleveland, Ohio

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NATIONAL ADVISORY COMMITTEE
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WASHINGTON

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

OCT 24 1957

RESEARCH MEMORANDUMHEAT OF COMBUSTION OF THE PRODUCT FORMED BY THE REACTION
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SUMMARY

The net heat of combustion of the product formed by the reaction of diborane with a mixture of acetylene and ethylene was found to be $20,440 \pm 150$ Btu per pound for the reaction of liquid fuel to gaseous carbon dioxide, gaseous water, and solid boric oxide. The measurements were made in a Parr oxygen-bomb calorimeter, and the combustion was believed to be 98 percent complete. The estimated net heat of combustion for complete combustion would therefore be $20,850 \pm 150$ Btu per pound.

INTRODUCTION

At the request of the Bureau of Aeronautics, Department of the Navy, the NACA is participating in a project (Project Zip) aimed at the discovery and evaluation of certain high-energy fuels. The NACA will determine the fundamental flame velocity and, in some cases, heat of combustion, and possibly other combustion properties of fuel samples submitted by companies participating in the project as contractors to the Bureau of Aeronautics, Department of the Navy.

A sample of material formed by the reaction of acetylene, ethylene, and diborane (AEDB) was received from the Callery Chemical Company. The heat of combustion of this material has been measured in a Parr oxygen-bomb calorimeter. Although the precision of the data is not equal to that obtained for hydrocarbons or the alkylsilanes (ref. 1) which have been studied, this special release memorandum has been prepared to make the data available as soon as possible.

TEST SPECIMEN

A group of samples, sealed in glass bulbs, was obtained from the Callery Chemical Company along with analytical data (table I). The samples were kept at dry-ice temperature until introduced into the bomb. The liquid weight varied from 0.2 to 0.5 gram, and several samples contained small amounts of suspended solids. The material was a yellow nonviscous liquid, and tests in this laboratory indicate that it is spontaneously inflammable in air.

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In all cases there was a small amount of carbonization at the point where the bulb was sealed off. This involved an insignificant amount of material. Three of the six sample bulbs received were filled incompletely and combustion could not be achieved in the Parr bomb.

APPARATUS AND PROCEDURE

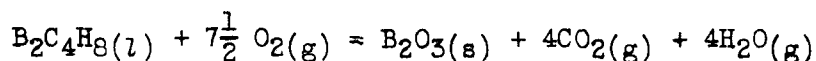
The apparatus consisted of a Parr adiabatic calorimeter equipped with an Illium constant-volume bomb and a mercury thermometer which could be read to $\pm 0.005^\circ \text{F}$. The procedure was identical with that described in reference 2.

RESULTS AND DISCUSSION

The results of three determinations of the heat of combustion of AEDB and the analysis of the combustion products are given in table II. The heats of combustion are the gross uncorrected values determined directly in the bomb with gaseous carbon dioxide, liquid water, and solid boric acid as the combustion products and with part of the boric acid dissolved in the water present in the bomb. Only runs 1 and 3 were used to obtain the average value, since in run 2 a visual inspection of the bomb showed that the combustion was not sufficiently complete. This gross heating value was $21,719 \pm 150$ Btu per pound. The determined percent carbon, as carbon dioxide, was much below the value reported by Callery Chemical Company, while the boron analysis was only slightly below the reported value.

To convert the uncorrected gross value to a corrected net value, it was necessary to know the chemical composition of the compound. The analysis obtained from the combustion process gave a B/C ratio of very close to $1/2$. The Callery value for active hydrogen indicated that there are roughly two active hydrogens for two boron atoms, and it was further considered that there are $1\frac{1}{2}$ inactive hydrogen atoms for each carbon atom (the average for ethylene and acetylene). This results in the formula $\text{B}_2\text{C}_4\text{H}_8$ if it is considered that the hydrogen bridge structure remains intact in the molecule.

The same type of corrections for converting the bomb value into a corrected net heat of combustion was employed as in reference 2. For the reaction



the heat of combustion was found to $20,440 \pm 150$ Btu per pound. The appearance of the combustion products indicated that the burning was about 98 percent complete. Therefore, a more reasonable value would be 20,850 Btu per pound.

Lewis Flight Propulsion Laboratory
National Advisory Committee for Aeronautics
Cleveland, Ohio, August 18, 1953

REFERENCES

1. Tannenbaum, Stanley, Kaye, Samuel, and Lewenz, George F.: Synthesis and Properties of Some Alkylsilanes. Jour. Am. Chem. Soc., vol. 75, no. 15, Aug. 5, 1953, pp. 3753-3757.
2. Tannenbaum, Stanley: The Heat of Combustion of Tetraethyldiborane. NACA RM E53E11, 1953.

TABLE I. - ANALYSIS OF PRODUCT REPORTED
BY CALLERY CHEMICAL COMPANY

Constituent	Percent
Carbon	61.5
Boron	26.2
Active hydrogen	2.9

TABLE II. - HEAT-OF-COMBUSTION DATA FOR AEDB

Experiment	Gross uncorrected heating values, Btu/lb	Analysis of com- bustion products	
		Carbon, percent	Boron, percent
1	21,660	56.0	23.5
2	21,427	55.7	24.9
3	21,777	56.4	24.5
Average (1 and 3)	21,719 $\pm$ 150	56.2	24.0
Corrected net value	20,440 $\pm$ 150		

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RESEARCH MEMORANDUM

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OF ACETYLENE, ETHYLENE, AND DIBORANE

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Fuels - Properties, Physical and Chemical 3.4.2

Combustion Research - General 3.5.1

Tannenbaum, Stanley

Abstract

The net heat of combustion of the product formed by the reaction of diborane with a mixture of acetylene and ethylene was found to be $20,440 \pm 150$ Btu per pound for the reaction of liquid fuel to gaseous carbon dioxide, gaseous water, and solid boric oxide. The measurements were made in a Parr oxygen-bomb calorimeter, and the combustion was believed to be 98 percent complete. The estimated net heat of combustion for complete combustion would therefore be $20,850 \pm 150$ Btu per pound.